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A Survey of Brown Shrimp Resources in the Northwestern Gulf of Mexico 1961-1965

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ABSTRACT

A sampling program was conducted during 1961-65 to measure the general distribution and abundance of shrimp resources off the Texas and Louisiana coasts. Samples were taken monthly with standard commercial shrimping gear along 10 transects at depths ranging from 14 to 110 m. Due to limitations of sampling, analysis of brown shrimp abundance data detected no significant differences between years, although 1961, 1962 and 1964 were historically low abundance years for brown shrimp. Generally, brown shrimp were most abundant at the 27 m stations during spring and summer, and moved progressively deeper during autumn and winter, when they were most abundant at 64 m stations. Brown shrimp were more abundant off the Texas coast than off the Louisiana coast. Distributions were similar to those of recent surveys of the area.

Female shrimp predominated in most catches, with an overall sex ratio of 1.20 during the study. Night catches were generally higher than day catches. Due to the diel differences in catchability, all shrimp sampling occurs at night during current surveys.

INTRODUCTION

A monthly survey of the shrimp resources off the Texas and Louisiana coasts was initiated in 1961 and continued through 1965. The primary purpose was to determine the general distribution and abundance of commercially important shrimp on a year-round basis. Biological data on shrimp (Kutkuhn, 1963; Temple and Fisher, 1965 and 1967; Brusher et al. 1972; Temple, 1973; Lyon and Baxter, 1974; Renfro and Brusher, 1982), finfish (Moore et al. 1970) and hydrography (Temple et al. 1977) were collected.

Nine species of shrimp occur in the Gulf of Mexico, but only brown (*Penaeus aztecus*), white (*P. setiferus*) and pink (*P. duorarum*) shrimp are caught in commercial quantities. Brown shrimp are most abundant off the Texas and Louisiana coasts, while white shrimp are caught mainly off the Louisiana coast. The pink shrimp fishery is concentrated off the southwest Florida coast.

This report examines the abundance of brown shrimp off the Texas and Louisiana coasts. Because diel differences in catchability influence interpretation of commercial fishing statistics of catch per unit effort and our methods of sampling shrimp populations, a detailed examination of these differences was made. The data presented in this report are unique in that measurements were made on a monthly basis along ten transects in the northwestern Gulf of Mexico over a four year period.

In 1981, a shrimp fishery management plan was implemented (Christmas and Etzold, 1977). One of the management measures proposed was the simultaneous closing of the territoral sea of the State of Texas and the adjacent Fishery

Conservation Zone (to 200 miles) to shrimp fishing during the time of year when small brown shrimp are migrating offshore from the estuaries. Information from historical long-term studies such as the one reported here may be useful in interpretation of results from the recent surveys conducted to determine the impact of such management measures (Klima et al. 1982).

METHODS

Sampling Procedures

The sampling procedures followed were discussed by Kimsey (1963, 1964). Shrimp were collected at stations established in depths of 14, 27, 46, 64, 82, and 110 m along 10 transects. Because the exact locations of the sampling sites were changed slightly several times during the study, a generalized set of transects (Fig. 1) was used in the analysis of the data collected. Samples from locations which did not lie on one of the transects were combined with those from a station of comparable depth on the nearest transect. Collections from depths other than the six categories listed above were assigned to the category nearest the actual depth. The time interval between sampling trips was about 1 month. Although stations were sometimes missed, the entire area was covered each month insofar as was possible, and no areas were neglected regularly.

A single flat otter trawl was used for all sampling. This trawl, the type used offshore by most shrimp fishermen, had a head-rope length of 14 m, a stretched mesh size of 5.7 cm, and was spread by otter boards measuring 2 m x 1 m. The net was towed at a speed of about 3 knots for 1 hour at each station. The tow for a particular sampling site was made when the boat arrived on station regardless of the time of day. About the same number of tows was made during the day as during night.

All brown shrimp caught were counted, and a subsample of 100 was taken and separated by sex. The total length (tip of rostrum to tip of telson) of each of the 100 shrimp was measured to the nearest millimeter. When less than 100 specimens were taken, sex determinations and measurements were made on all shrimp in the sample.

Computational Procedure

Comparisons of abundance, defined as number of shrimp caught per 1 hour tow, were made between areas rather than between specific sampling sites because of the addition and deletion of several stations. For this analysis we arbitrarily divided the northwestern Gulf into four study areas (Fig. 1). The total of 1,799 trawl samples taken during this study was distributed among these four areas each year (Table 1). Day and night catches were separated because of apparent diel differences in catchability.

Abundance data were examined using two separate three-way analyses of variance rather than a four-way analysis because of the complexity of the latter with unequal cell frequencies. Although some loss of information may result from using the two three-way designs, the tests of significance are conservative; that is, significant differences observed from the three-way treatment would be highly significant if a four-way treatment were used.

In comparisons of abundance between seasons, the seasons were defined as follows: spring - April, May, and June; summer - July, August, and September; autumn - October, November, and December; and winter - January, February, and March.

RESULTS AND DISCUSSION

Day-Night Differences in Catchability

A summary of the general diel differences in catchability is presented in Figure 2. Values represented are ratios of mean catch per unit of effort (number per 30 minute tow) during the day to mean catch per unit of effort at night. These are shown for each of the four areas by year, season, and depth. Catch per unit of effort during the day divided by catch per unit of effort at night would equal 1.0 if no diel difference in catchability existed.

The relations of day to night catchability are fairly consistent with respect to years, seasons, and depths in all cases except in area 4 (Figure 2). During 1961-63 the average day catches were within the range of 25% to 45% of the night catches, except for area 4 in 1963 when day catches were higher than night catches. During 1964 and 1965 average day catches were 6% to 46% of the night catches, except for area 4 in 1965 when day catches were 2.4 times greater than the night catches. The consistency of the values for areas 1, 2, and 3 is striking on a year-to-year basis. The apparent reversals in the day-night ratios for area 4 can be explained in part by biased sampling. In 1963, there were very large numbers of shrimp (most likely small migrating shrimp) taken at two 27 m stations during the day in June.[1] These two data points biased the ratio in favor of higher day catch for both year and season for area 4. The 1965 peak in area 4 was probably due in part to fewer samples taken that year (Table 1) and the sampling of more stations likely to yield shrimp (27-46 m) during the day than at night. Other possible factors will be discussed later in this section. The significant interaction in the analysis of variance between areas and day-night is indicative of differences

[1] 856 at station 68 and 1852 at station 65 (Lyon and Baxter, 1974 p. 32).

in diel behavior patterns that affected catchability differently in the four sampling areas. The differences between day and night catches were more pronounced in areas 1 and 2 than in areas 3 and 4 (Table 2).

The ratio of day to night catches changes with the depth at which samples are taken. Data from areas 1, 2, and 3 were similar in that the day to night ratio of catch per unit of effort was high (0.61-0.74) at the 14 m stations, low (0.05-0.35) at the 27 to 64 m stations, and intermediate (0.21-0.56) at the 82 and 110 m stations. Day catches were relatively high in area 4 within the depth range 27-64 m.

Several researchers found similar results pertaining to the diel catchability of penaeid shrimp. Springer and Bullis (1952), Ingle (1957), and Kutkuhn (1961) reported that *P. aztecus* is more vulnerable to fishing gear at night than during the day. Racek (1959) reported that catches of *Penaeus plebejus* Hess were larger at night than during the day. Catches of *P. setiferus* along the northeast coast of Florida (Joyce 1965) were larger during the day than during the night for shrimp 65-155 mm in length in inshore waters. Catches were about the same during the day and night for shrimp larger than 115 mm in inshore waters and for shrimp 65-165 mm in offshore waters. Joyce noted that catches of *P. aztecus* in the same area were larger during the day in inshore waters, and about the same for night and day in offshore waters.

Although we made no light penetration measurements, it is possible that catchability is influenced by light. Fuss and Ogren (1966) observed a tendency of *P. duorarum* to burrow in the presence of solar light and noted that maximum activity did not occur until incident illumination was below 0.01076 lumens per m^2 (about 1 hr after sunset). Turbid waters near shore may limit the penetration of light so that day and night light intensities on the bottom in 14 m of water are similar. The water at deeper stations is less turbid, allowing light to penetrate further, except that bottom light intensities diminish with depth. Because area 4 is adjacent to the mouth of the Mississippi River, periods of heavy discharge from the Mississippi River increase turbidity in the area sampled and may thereby increase the catchability of brown shrimp during periods of daylight. An average rate of flow for the Mississippi and Atchafalaya Rivers combined is presented for each month of the years 1961-65 (Fig. 3). The high discharge rates during March, April and May would correspond with the relatively large daytime catches during the spring in area 4 (see seasonal comparison in Fig. 2). Years during which the total discharge was high (1961 and 1962) do not correspond to years with large daytime catches (1963 and 1965).

Surface salinity data compiled by Temple et al. (1977) were useful in determining the areas influenced by the outflow from the Mississippi and Atchafalaya Rivers at different times during 1963-65. A westerly flow of river water prevailed throughout the year. During April through June the low salinity water was held close to shore as it moved to the west. It is during this period that river water would be most likely to have had an influence on the turbidity at our sampling sites (14-64 m). These data add credence to the theory that turbidity may have been partially responsible for the large daytime catches.

Distribution and Abundance

No general annual changes in shrimp abundance were apparent from the analyses of variance of the data. Based on our sampling we could not distinguish statistically between the overall levels of abundance from year to year within the sampling period.

The data presented in Table 5 are mean catches per tow for all samples taken during the 5-year period at a particular location during the season. While the data reflect only general differences, these differences are meaningful if they are consistent at several locations throughout the period of the study. A remarkable regularity was observed when data were arranged in this fashion. Shrimp were most abundant at the 27 m stations along most transects during the spring and summer months, but moved progressively toward deeper water during autumn and winter. By winter, shrimp were generally most abundant at the 64 m depth. Highly significant (1% level) differences were observed in levels of shrimp abundance at different depths (Table 4). Brown shrimp were generally more abundant in 27-46 m than at depths of less than 27 m or in 47-110 m (Table 3). Matthews (1982) found the greatest abundance of brown shrimp along Texas during June and July to be in depths between 18 and 36 m.

The distribution of shrimp with depth and season is determined by the magnitude and timing of recruitment into the population, the movements of shrimp after they have been recruited (Klima, Baxter and Patella, 1982), and the mortality rates acting within the population. Although the sampling conducted during this study was not adequate to provide movement data on a monthly basis, general bathymetric movement data are available on a seasonal basis (Fig. 4).

Temple et al. (1977) compiled temperature data collected in conjunction with this study. Average bottom temperature ranges in the areas of greatest brown shrimp abundance were 17-26°C in the spring and 22-28°C in the summer months. During late summer and autumn, large concentrations of shrimp moved to deeper water at about the time bottom temperatures reached maximum values at the 46 m depth (24-27°C). During late autumn and winter many shrimp moved to the 64 m depth where temperatures were not different from those in 46 m of water (17-20°C).

Abundance, as reflected by average catch per unit of effort, was highest during summer, slightly lower during autumn, and markedly lower in the winter and spring (Table 5).

A highly significant difference between the mean catches in numbers from the four different areas was observed when the data were treated with the analysis of variance calculations. The overall means (weighting each sample equally) for the four areas were as follows: area 1, 73.2; area 2, 65.2; area 4, 47.3; and area 3, 38.2. Using Tukey's test (Tukey 1953, Snedecor 1956), we found the least significant differences in abundance can be summarized as follows: brown shrimp were more abundant in area 1 than in areas 3 and 4, and more abundant in area 2 than in area 3. The weights of commercial landings from these areas agree fairly well with these differences; commercial landings of brown shrimp were greater from areas 1 and 2 than from areas 3 and 4. The relatively uniform distribution of shrimp over much of the study area is indicative of a large area of suitable habitat. In contrast, the catches along transects 6 and 7 (area 3) were consistently low throughout the year (Fig. 4).

Relative Abundance of Male and Female Shrimp

The relative abundance of male and female shrimp is expressed in Table 6 as a ratio of the number of females to the number of males caught along a given transect at a given depth during the course of this study. Females were predominant in the catches at most stations, however this information may be biased. Male shrimp are smaller than females of the same age subsequently males make up a larger proportion of small shrimp (< 150 mm) escaping through the net meshes.

No major changes in the sex ratio between seasons were apparent when data for all depths are combined, but the depths at which males were in greatest relative abundance were not the same from season to season (Table 6). Males and females were taken in about equal numbers in catches from the 46 m stations in the winter and from the 27, 46, and 82 m stations in the spring. Males were more abundant than females in catches at 46 and 64 m stations during the summer and at the 64 m station in the autumn.

Joyce (1965) reported catching _P. aztecus_ males and females in about equal numbers in inshore waters (mode of 115 mm total length). Weymouth, Lindner, and Anderson (1933) observed fairly constant sex ratios of about 1.08 for _P. setiferus_ between September and April and segregation of the sexes from May through August with ratios of from 0.47 to 5.25 associated with spawning. The sex ratio for all samples taken during the 5-year period of this study was 1.20.

SUMMARY

1. Shrimp catches were generally higher at night than during the day, regardless of year season or depth.

2. Shrimp were most abundant at 27 m stations along most transects during spring and summer and moved into deeper waters (to 64 m) during autumn and winter.

3. Average catch per unit effort was highest in summer, when shrimp were also the smallest in size.

4. Catches of brown shrimp were higher off Texas than off Louisiana.

5. The overall ratio of female to male shrimp during the study was 1.20.

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TABLE LEGENDS

TABLE 1. Mean numbers of brown shrimp caught per hour by biological years, areas, and time of day, Texas and Louisiana coasts, 1961-65.

TABLE 2. Summary of three-way analysis of variance calculations of catch per tow using classifications: Biological Years, Areas, and Day-Night.

TABLE 3. Mean numbers of brown shrimp caught per hour by biological years, depths, and time of day, Texas and Louisiana coasts, 1961-65.

TABLE 4. Summary of the three-way analysis of variance calculations of catch per tow using classifications: Biological Years, Depths, and Day-Night.

TABLE 5. Average catch of brown shrimp per tow by seasons, sex, depths, and transects, 1961-65.

TABLE 6. Sex ratio (No. females/No. males) for each transect by seasons and depths, all years combined, Texas and Louisiana coasts, 1961-65.

TABLE 1

Mean numbers of brown shrimp caught per hour by biological years,[1] areas, and time of day, Texas and Louisiana coasts, 1961-65.

Biological year	Area	Day: Number of samples	Day: Average catch	Night: Number of samples	Night: Average catch	Day and night: Number of samples	Day and night: Average catch	Yearly means, areas weighted equally
7/61-6/62	1	64	34.2	53	72.1	117	51.4	
	2	55.	20.0	58	113.4	113	67.9	
	3	54	18.9	63	41.7	117	31.2	
	4	55	34.2	79	77.1	134	59.5	52.5
Total		228		253		481		
7/62-6/63	1	87	25.4	81	132.0	168	76.8	
	2	52	22.9	52	106.3	104	64.6	
	3	69	11.3	58	53.8	127	30.7	
	4	83	56.6	72	63.8	155	59.9	58.0
Total		291		263		554		
7/63-6/64	1	80	44.1	55	139.4	135	82.9	
	2	43	39.7	36	109.9	79	71.7	
	3	59	14.0	44	78.4	103	41.5	
	4	57	26.4	43	64.9	100	43.0	59.8
Total		239		178		417		
7/64-6/65	1	63	49.9	55	118.4	118	81.8	
	2	28	3.8	39	94.3	67	56.5	
	3	40	43.1	38	55.7	78	49.2	
	4	47	20.7	37	34.5	84	26.8	53.6
Total		178		169		347		
Total samples		936		863		1,799		
Means, years and areas weighted equally			29.1		84.7		56.0	

	Area	1	2	3	4
Areal means, years weighted equally		73.2	65.2	38.2	47.3

[1] The biological year is defined as July 1-June 30 to correspond with annual recruitment to the offshore populations.

TABLE 2

Summary of three-way analysis of variance calculations of catch per tow using classifications: Biological Years, Areas, and Day-Night.

Source	Sum of squares	Degrees of freedom	Mean square	F
Total	32,436,889.16	1,798		
Biological Years	46,805.81	3	15,601.94	0.919
Areas	351,222.17	3	117,074.03	6.899**
Day-Night	1,295,185.38	1	1,295,185.38	76,328**
Years x Areas	171,433.86	9	19,048.20	1.123
Years x Day-Night	28,987.02	3	9,662.34	0.569
Areas x Day-Night	270,696.44	3	90,232.14	5.318**
Years x Areas x Day-Night	118,520.46	9	13,168.94	0.776
ERROR	29,983,780.25	1,767	16,968.75	

** Significant at the 1-% level.

TABLE 3

Mean numbers of brown shrimp caught per hour by biological years, depths, and time of day,

Texas and Louisiana coasts, 1961-65.

Biological Year	Station depth (m)	Day: Number of samples	Day: Average catch	Night: Number of samples	Night: Average catch	Day and Night: Number of samples	Day and Night: Average catch	Depth means, years weighted equally: Depth	Depth means, years weighted equally: Mean
7/61-6/62	<27	53	25.8	29	7.0	82	19.2	<27	33.8
	27- 46	72	36.9	106	105.2	178	77.6	27- 46	95.9
	47-110	103	21.1	118	65.8	221	45.0	47-110	24.2
Total		228		253		481			
7/62-6/63	<27	71	19.2	64	77.2	135	46.7		
	27- 46	106	59.2	98	161.5	204	108.3		
	47-110	114	10.9	101	31.3	215	20.5		
Total		291		263		554			
7/63-6/64	<27	126	31.5	70	44.1	196	36.0		
	27- 46	77	42.2	81	166.3	158	105.8		
	47-110	36	9.4	27	48.5	63	26.2		
Total		239		178		417			
7/64-6/65	<27	100	25.7	89	42.1	189	33.4		
	27- 46	67	49.9	76	128.9	143	91.9		
	47-110	11	3.4	4	9.8	15	5.1		
Total		178		169		347			
Total samples		936		863		1,799			

TABLE 4

Summary of the three-way analysis of variance calculations of catch per tow using classifications: Biological Years, Depths and Day-Night.

Source	Sum of squares	Degrees of freedom	Mean square	F
Total	32,436,893.19	1,798		
Biological Years	49,489.90	3	16,496.63	1.021
Depths	805,099.97	2	402,549.98	24.921**
Day-Night	458,648.25	1	458,648.25	28.393**
Years x Depths	106,100.71	6	17,683.45	1.095
Years x Day-Night	38,939.10	3	12,979.70	0.803
Depths x Day-Night	247,281.57	2	123,640.79	7.654**
Years x Depths x Day-Night	64,985.62	6	10,830.94	0.670
ERROR	28,672,137.03	1,775	16,153.31	

** Significant at the 1-% level.

TABLE 5

Average number of brown shrimp per tow by seasons, sex, depths and transects, 1961-1965.

Transect number	Approximate depth (meters)					
	14	27	46	64	82	110
SPRING (Females)						
1	9.6	219.6	25.0	12.4	3.0	13.0
2	94.6	65.3	13.3	1.0	6.4	4.5
3	25.6	92.7	55.2	19.0	6.0	13.0
4	20.0	4.7	27.3	6.0	6.6	15.5
5	14.1	100.5	17.9	0.2	3.3	2.2
6	23.6	3.0	10.7	3.0	12.7	1.7
7	3.8	10.1	34.9	7.0	3.0	12.7
8	21.3	60.0	24.4	23.6	49.7	5.5
9	9.5	128.8	31.2	31.3	11.9	0.5
10	7.2	62.4	19.1	24.3	25.2	0.0
Mean (weighting each transect equally)	22.93	74.71	25.90	12.78	12.78	6.86
(Males)						
1	1.2	112.4	19.0	22.6	2.0	17.9
2	22.4	56.3	18.8	1.5	9.6	1.0
3	16.0	60.7	57.4	4.4	7.5	8.5
4	8.0	8.3	15.6	7.0	6.0	13.5
5	9.0	114.2	14.8	0.2	2.1	2.1
6	11.8	2.9	14.7	1.5	16.2	1.7
7	1.6	8.8	29.8	5.0	4.1	8.6
8	12.0	79.0	27.6	15.7	33.6	5.0
9	4.7	90.8	34.1	24.4	65.4	0.0
10	5.2	44.2	28.7	18.0	15.4	0.0
Mean (weighting each transect equally)	9.19	57.76	26.05	10.03	16.19	5.83

TABLE 5 (Continued)

Transect number	Approximate depth (meters)					
	14	27	46	64	82	110
SUMMER						
(Females)						
1	0.9	103.0	15.7	9.0	2.6	0.2
2	77.6	143.8	59.9	7.6	4.7	5.6
3	28.9	162.0	33.7	6.0	2.8	2.0
4	39.9	38.7	2.0	3.0	6.0	0.0
5	92.0	135.1	36.0	0.3	3.7	1.8
6	14.8	48.1	55.7	8.0	7.9	2.5
7	54.5	57.0	66.9	12.5	6.3	4.0
8	61.3	81.7	27.8	20.6	22.3	4.0
9	19.7	46.9	14.7	67.3	12.3	1.7
10	17.5	41.5	72.0	27.0	11.7	0.0
Mean (weighting each transect equally)	40.71	85.78	38.44	16.13	8.03	2.18
(Males)						
1	1.2	136.1	16.9	10.5	10.0	0.2
2	22.1	130.9	82.3	8.7	6.2	2.7
3	9.4	152.0	34.3	8.3	4.2	1.8
4	24.5	67.9	2.3	5.0	3.2	0.0
5	36.7	131.2	34.6	1.7	1.7	2.0
6	8.4	33.9	57.2	7.3	9.5	1.5
7	41.2	35.8	77.8	13.0	7.1	3.6
8	51.3	117.0	38.7	29.4	9.0	2.5
9	9.2	59.2	21.2	35.2	12.7	1.9
10	13.6	17.2	97.6	33.6	24.9	0.0
Mean (weighting each transect equally)	21.76	88.12	46.29	15.27	8.85	1.62

TABLE 5 (Continued)

Transect number	Approximate depth (meters) 14	27	46	64	82	110
AUTUMN						
(Females)						
1	16.0	67.5	67.4	33.5	2.7	0.0
2	70.7	64.3	33.8	8.4	18.2	0.0
3	20.5	103.6	72.6	43.4	41.7	10.7
4	14.8	60.7	105.6	63.0	29.3	0.2
5	12.0	63.1	100.8	0.5	4.6	0.1
6	4.2	10.6	58.7	11.0	8.6	1.5
7	0.8	42.9	50.7	14.6	20.0	11.6
8	0.5	37.6	56.7	41.2	18.7	9.5
9	7.5	24.4	29.6	19.4	8.8	1.0
10	4.6	34.4	39.6	29.9	74.4	0.0
Mean (weighting each transect equally)	15.16	50.91	61.55	26.49	22.70	3.46
(Males)						
1	9.8	41.5	61.4	48.8	2.3	0.0
2	28.5	61.7	36.8	29.3	24.9	0.0
3	7.7	98.7	74.3	45.8	26.6	8.3
4	2.0	64.4	58.2	70.6	19.1	0.0
5	5.2	58.0	76.6	0.5	2.7	0.1
6	1.6	6.7	36.2	14.0	12.9	0.2
7	0.5	30.1	33.8	23.4	22.2	9.4
8	0.2	18.0	53.0	35.6	14.5	4.8
9	4.2	18.7	31.9	30.5	11.7	0.0
10	2.0	23.5	44.2	17.6	46.2	0.0
Mean (weighting each transect equally)	6.17	42.13	50.64	31.61	18.31	2.28

TABLE 5 (Continued)

Transect number	Approximate depth (meters)					
	14	27	46	64	82	110
WINTER						
(Females)						
1	0.0	4.9	46.1	127.1	65.0	8.0
2	0.2	9.4	49.7	19.8	25.1	15.0
3	2.1	23.9	20.3	43.5	33.6	21.0
4	0.3	20.1	43.0	17.4	30.9	38.7
5	0.2	49.1	32.8	4.3	13.7	7.0
6	0.6	9.5	40.1	29.0	11.8	1.5
7	0.1	16.6	30.9	22.1	10.0	5.0
8	0.0	18.9	61.1	89.4	37.8	1.7
9	0.0	10.0	15.8	75.0	70.4	2.7
10	0.2	18.6	28.4	62.8	30.4	6.3
Mean (weighting each transect equally)	0.37	18.10	36.82	49.04	32.87	10.69
(Males)						
1	0.0	5.1	29.8	26.4	22.0	6.0
2	0.2	9.8	43.8	29.9	6.8	15.0
3	1.0	29.0	24.7	36.8	11.8	24.0
4	0.0	17.9	18.7	34.9	21.7	9.3
5	0.1	53.0	27.2	2.3	8.7	8.2
6	0.3	4.7	36.2	15.6	20.0	0.5
7	0.0	10.7	19.9	33.8	24.9	11.6
8	0.0	6.8	75.2	62.2	37.7	3.0
9	0.0	12.4	32.8	47.4	46.0	2.0
10	0.0	11.5	33.1	71.8	27.7	0.6
Mean (weighting each transect equally)	0.16	16.09	34.14	36.11	22.73	8.02

TABLE 6

Sex ratio (No. females/No. males) for each transect by seasons and depths, all years combined, Texas and Louisiana coasts, 1961-65.

Transect number	Depth (m)						
	14	27	46	64	82	110	Unweighted means
SPRING							
1	8.00	1.95	1.32	0.55	1.50	0.73	2.34
2	4.22	1.16	0.71	0.67	0.67	4.50	1.99
3	1.60	1.53	0.96	4.32	0.80	1.53	1.79
4	2.50	0.57	1.75	0.86	1.10	1.15	1.32
5	1.57	0.88	1.21	1.00	1.57	1.05	1.21
6	2.00	1.03	0.73	2.00	0.78	1.00	1.26
7	2.38	1.15	1.17	1.40	0.73	1.48	1.38
8	1.78	0.76	0.88	1.50	1.48	1.10	1.25
9	2.02	1.42	0.91	1.28	0.18	--	1.16
10	1.38	1.41	0.66	1.35	1.64	--	1.29
Unweighted means	2.74	1.19	1.03	1.49	1.04	1.57	
SUMMER							
1	0.75	0.76	0.93	0.86	0.26	1.00	0.76
2	3.51	1.10	0.73	0.87	0.76	2.07	1.51
3	3.07	1.06	0.98	0.72	0.67	1.11	1.27
4	1.63	0.57	0.87	0.60	1.88	--	1.11
5	2.51	1.03	1.04	0.18	2.18	0.90	1.31
6	1.76	1.42	0.97	1.10	0.83	1.67	1.29
7	1.32	1.59	0.86	0.96	0.89	1.11	1.12
8	1.19	0.70	0.72	0.70	2.48	1.60	1.23
9	2.14	0.79	0.69	1.91	0.97	0.89	1.23
10	1.29	2.41	0.74	0.80	0.47	--	1.14
Unweighted means	1.92	1.14	0.85	0.87	1.14	1.29	

TABLE 6 (Continued)

Transect number	Depth (m)						
	14	27	46	64	82	110	Unweighted means
AUTUMN							
1	1.63	1.63	1.10	0.69	1.17	--	1.24
2	2.48	1.04	0.92	0.29	0.73	--	1.09
3	2.66	1.05	0.98	0.95	1.57	1.29	1.42
4	7.40	0.94	1.81	0.89	1.53	--	2.51
5	2.31	1.09	1.32	1.00	1.70	1.00	1.40
6	2.62	1.58	1.62	0.78	0.67	7.50	2.46
7	1.60	1.42	1.50	0.62	0.90	1.23	1.21
8	2.50	2.09	1.07	1.16	1.29	1.98	1.68
9	1.78	1.30	0.93	0.64	0.75	--	1.08
10	2.30	1.46	0.90	1.70	1.61	--	1.59
Unweighted means	2.73	1.36	1.22	0.87	1.19	2.60	
WINTER							
1	--	0.96	1.55	4.81	2.95	1.33	2.32
2	1.00	0.96	1.13	0.66	3.69	1.00	1.41
3	2.10	0.82	0.82	1.18	2.85	0.88	1.44
4	--	1.12	2.30	0.50	1.42	4.16	1.90
5	2.00	0.93	1.20	1.87	1.57	0.85	1.40
6	2.00	2.02	1.11	1.86	0.59	3.00	1.76
7	--	1.55	1.55	0.65	0.40	0.43	0.92
8	--	2.78	0.81	1.44	1.00	0.57	1.32
9	--	0.81	0.48	1.58	1.53	1.35	1.15
10	--	1.62	0.86	0.87	1.10	10.50	2.99
Unweighted means	1.78	1.36	1.18	1.54	1.71	2.41	
ALL SEASONS							
Unweighted means	2.29	1.26	1.07	1.19	1.27	1.97	

FIGURE LEGENDS

FIGURE 1. Study areas used for anlytical comparisons (transect locations are marked by broken lines and numbered in parentheses).

FIGURE 2. The ratio of catch (numbers) per unit of effort during the day to catch per unit of effort at night for four geographical areas by years, seasons, and depths.

FIGURE 3. Average rate of flow of the Mississippi and Atchafalaya Rivers on a monthly basis for 1961-65.

FIGURE 4. Seasonal distribution of brown shrimp at sampling sites by depth in four areas, 1961-65 (spring, April-June; summer, July-September; autumn, October-December; winter, January-March).

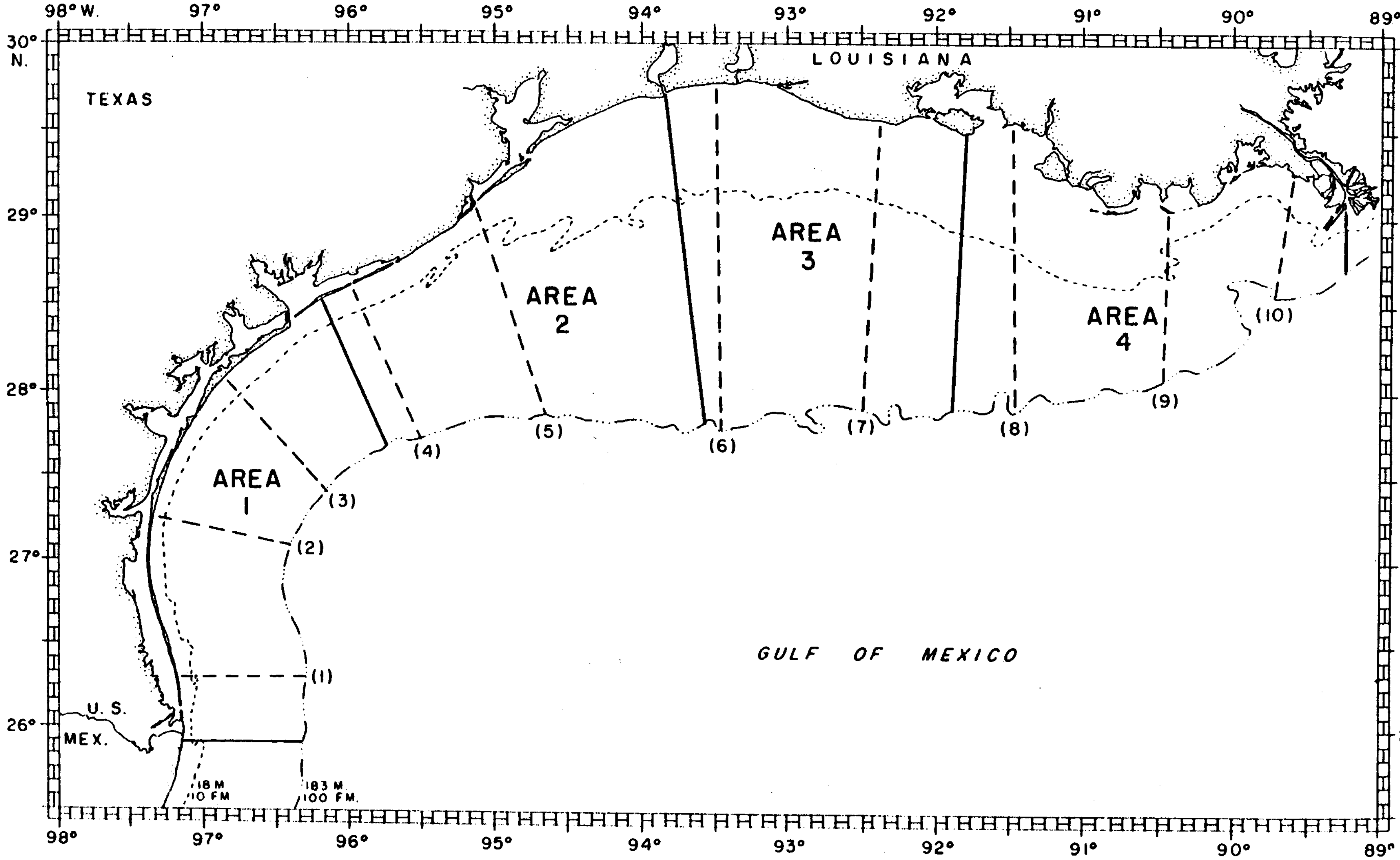

Figure 1. Study areas used for analytical comparisons (transect locations are marked by broken lines and numbered in parentheses).

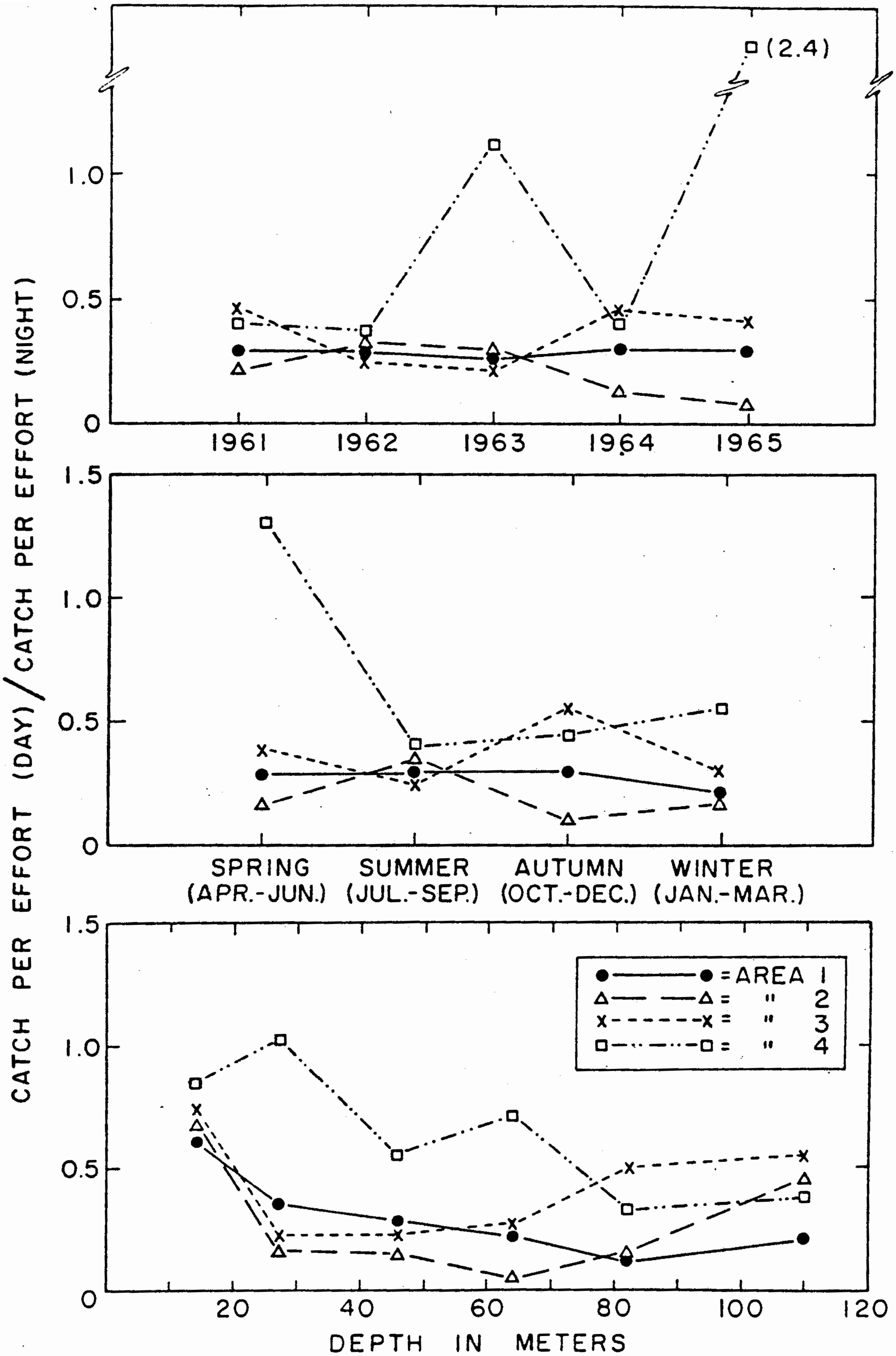

Figure 2. The ratio of catch (numbers) per unit of effort during the day to catch per unit of effort at night for four geographical areas by years, seasons and depths.

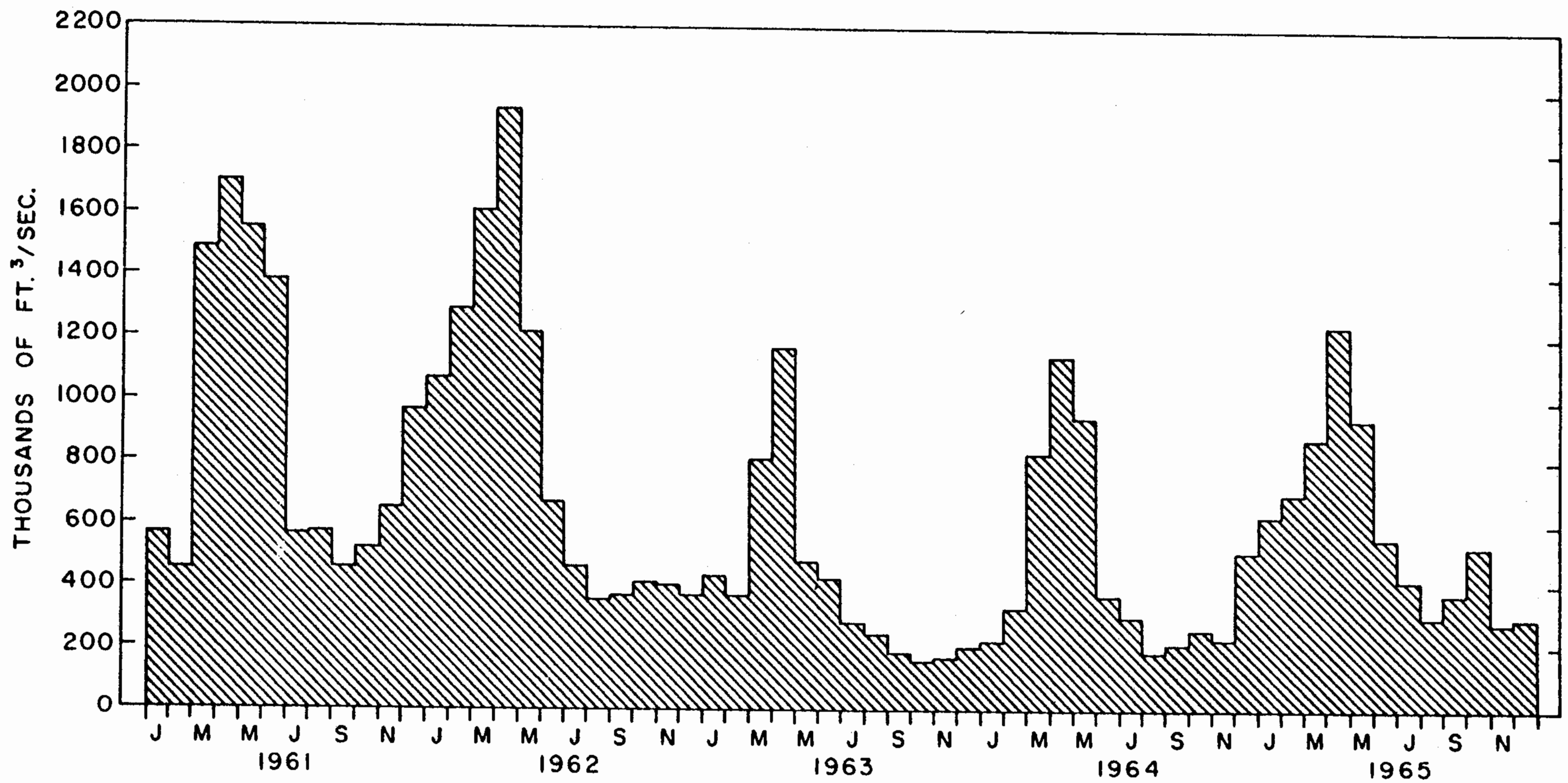

Figure 3. Average rate of flow of the Mississippi and Atchafalaya Rivers on a monthly basis for 1961-65.

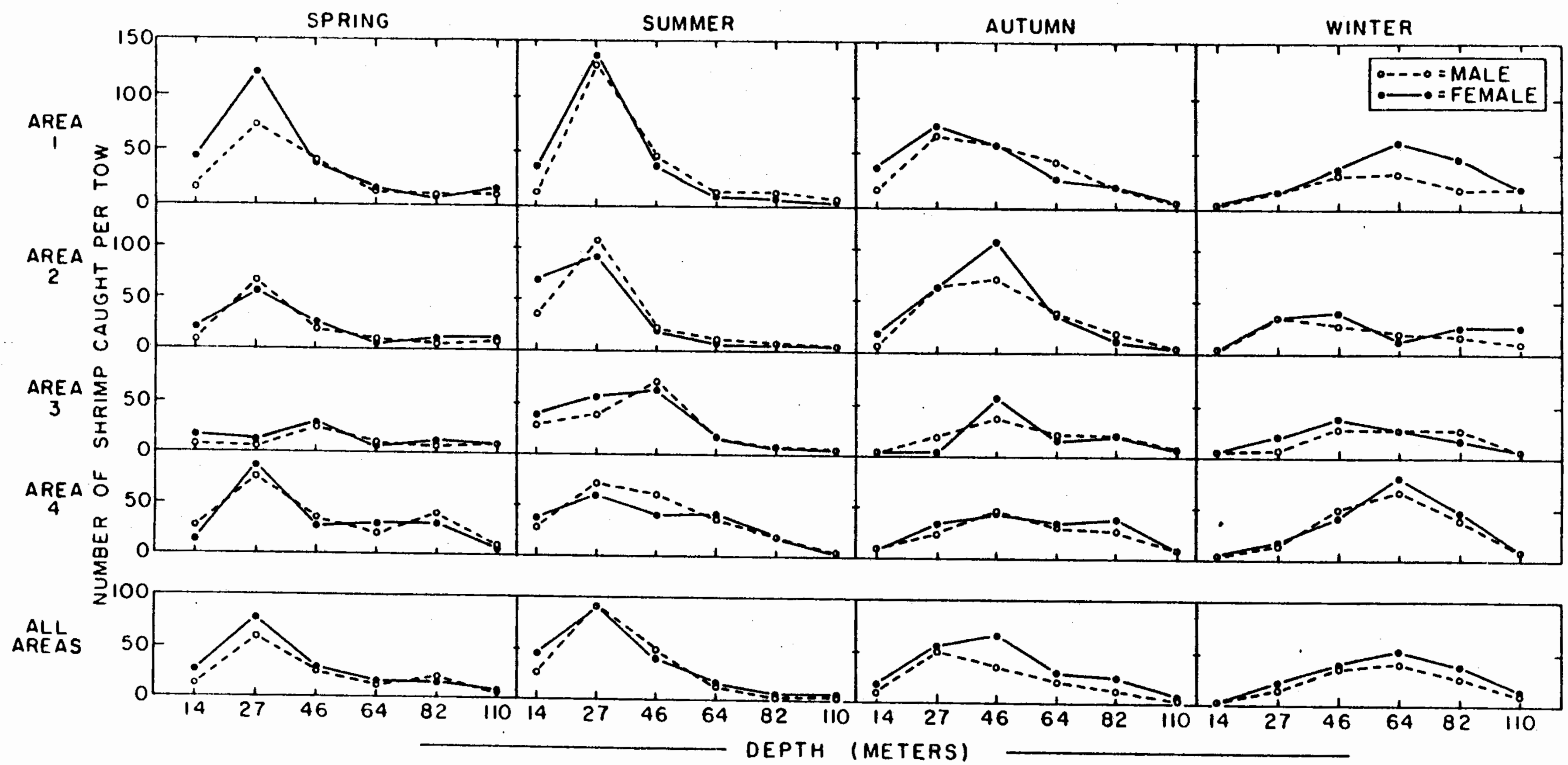

Figure 4. Seasonal distribution of brown shrimp at sampling sites by depth in four areas, 1961-65 (spring, April-June; summer, July-September; autumn, October-December; winter, January-March).